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December 10, 2015

Ms Eliza Cox
Nutter McClennan & Fish LLP
Seaport West
155 Seaport Boulevard
Boston, MA 02210

Subject: Sound study report for Heritage Museums & Gardens Adventure Park
Reference: HMMH Project No. 307710

Dear Ms Cox:

This letter provides a report on a sound study that HMMH conducted on behalf of Heritage Museums & Gardens on their recently-opened outdoor aerial Adventure Park. The purpose of the sound study was twofold. First, the study determined the extent to which sound from the Adventure Park would be audible, cause nuisance and affect the use of the property at the Highview Condominiums on Highview Drive. Second, the study determined if sound from the Adventure Park would likely cause a violation of the Massachusetts Department of Environmental Protection's noise policy.

This report first provides a summary of the study and findings, then provides more details of the observations during the site visit, the sound measurements and the noise prediction analysis. At the end of the report, Appendix A explains the sound metrics used in this report.

Summary of Study and Findings

HMMH conducted attended sound monitoring and listening in the area of the Highview Condominiums on two occasions. The first was on August 27, 2015 on Heritage property slightly closer to the Adventure Park than the Highview Condominiums. The second occasion was on October 17, 2015 on the outdoor deck of the Highview Condominiums common building. Both days were mostly clear with light winds primarily from the northwest and west, which was favorable for enhanced sound propagation from the Adventure Park to the condominiums, which are southeast of the park. Monitoring and listening were conducted in the morning before the park opened and again in the late morning after the park was full to capacity with guests.

At no time during either monitoring with the park in operation were any sounds from the park audible at all. The background sound levels were quite low, and were dominated by

traffic on Route 6 and Highview Drive, birds, and crickets, with contributions from occasional aircraft. During the August measurement period, sound from activities at the Heritage maintenance facility were audible and contributed to the measured ambient background sound levels prior to all maintenance activities being stopped to allow for measurements unaffected by them.

HMMH also conducted measurements of the sounds generated by the Adventure Park activities at the park itself to obtain reference "source" sound levels that could be used to predict sound levels at other distances. These reference levels were obtained when the park was operating at full capacity with people on all of the commonly-used aerial routes. The reference levels were used to compute sound levels from the Adventure Park at the Highview Condominiums deck using worst-case sound-propagation assumptions. We assumed downwind conditions from source to receiver and minimal additional attenuation from the terrain and thick foliage that exists between the source area and the Highview deck. The predicted Adventure Park sound levels, both average and maximum, are well below the measured ambient sound levels at the site near the Highview Condominiums. This explains why the Adventure Park was not audible at all during the monitoring near the condominiums under favorable sound propagation conditions. Even if no attenuation is attributed to foliage or terrain, the predicted Adventure Park sound levels are below the measured ambient sound levels.

Therefore, HMMH concludes that under normal full-capacity operation of the Adventure Park, sounds from the park will not be audible at the Highview Condominiums, even under atmospheric conditions favorable to sound propagation. As a result, we conclude that there is no potential for annoyance or nuisance associated with sound from the park under normal operation.

HMMH conducted additional modeling of human screaming, based on data HMMH has in our files collected from roller coaster sound studies. There were no screams heard during our either of our site visits and measurements in the Adventure Park, however, we realize there is the potential for an occasional scream from a particularly excited guest. Based on the roller coaster scream data, we estimate that there is some potential for screams from the Park to be audible during the quietest periods of background sound levels that we measured near the Condominiums. As a result, while there is the potential for an occasional scream from the Park to be heard outdoors at the Highview deck under atmospheric conditions favorable to sound propagation, such potential audibility at such low sound levels does not approach normal standards for annoyance or nuisance.

The Massachusetts Department of Environmental Protection (MassDEP) has a published noise policy under their noise regulation (310 CMR 7.10), whereby a violation occurs if a noise source increases the broadband background sound level by more than 10 dBA. Since

normal operation of the Adventure Park does not affect the background sound level at all, and even momentary screams could only increase the background sound level slightly, there is no potential for the Adventure Park to cause a violation of the MassDEP noise policy.

Site Visits and Measurements

Measurements on August 27, 2015

On Thursday, August 27, 2015 HMMH visited the Heritage Museums and Gardens property to collect sound measurements, listen to the audible sources of sound in the community and observe and collect sound measurements at the Adventure Park. August 27th was chosen for the measurements because light winds from the northwest were forecast, which are the atmospheric conditions favorable to sound propagation from the Adventure Park to the Highview Condominiums. Winds from the west and north also have downwind components in the source-receiver direction, so are also considered favorable to sound propagation. HMMH observed winds from the northwest and west that day, and the wind data from the Otis Air National Guard weather station corroborates HMMH's observations.

The site selected on Heritage Museums property near the Condominiums for sound level measurements comparable to what would be heard at the Highview deck was in a line between the deck and the Adventure Park just to the northwest of Highview Drive. Figure 1 is an aerial photograph of the study area showing the locations of the Adventure Park, the Highview Condominium outdoor deck and Site 1, where the measurements near the condominiums were conducted. Ambient sound level measurements[1] were conducted between approximately 8:40 AM and 9:00 AM, just prior to the opening of the Adventure Park. Background sound levels averaged around 45 dBA, with the dominant sources of sound being traffic on Route 6 and crickets; winds were calm. The metric "dBA" refers to A-weighted decibels, which is the standard metric used worldwide to gauge how noise relates to human response. Appendix A at the end of this report provides a description of A-weighted decibels as well as a chart showing common outdoor and indoor sound levels in dBA. Figure 2 shows a time-history graph of the measured sound levels at Site 1 during this period. There are annotations on the graph showing sources of sound including when activity at the Heritage Museums maintenance garage was occurring and an aircraft flyover. Since the distance between Site 1 and Route 6 is similar to the distance between

[1] All of HMMH's sound measurement instrumentation is calibrated regularly by an independent laboratory with calibrations traceable to the National Institute of Standards and Technology. In addition, our measurements are always field-calibrated with an acoustic calibrator before and after each measurement.

the Highview deck and Route 6, we would expect sound levels on the Highview deck to be quite similar.

HMMH returned to Site 1 to conduct measurements between 11:00 AM and 11:30 AM, when the park was full to capacity with guests on the aerial courses. By this time of the morning, the background sound levels had dropped somewhat, with less Route 6 traffic and less cricket sound. Winds remained calm at the ground the entire time, with gentle wind observable in the upper trees from time to time. Average sound levels were around 40 dBA, with maximum levels up to over 55 dBA from aircraft overflights and trucks on Route 6. Figure 2 shows an annotated time-history graph of the measured sound levels at Site 1 during the period of Park operation. As mentioned in the summary above, a log of audible sound sources and events was kept during the entire measurement period, and at no time were any sounds from the Adventure Park audible.

Based on the modest variations in sound levels, the nature and variability of the audible sound sources and the slight variations in wind during both measurement periods, I determined that 20- to 30-minute measurement periods were scientifically valid and representative of those times of day.

HMMH's reference source measurements of activities at the Adventure Park were conducted at Site 3 as shown on Figure 1. The site was located southeast of the back of the park in the direction of the condominiums, 60 feet from the nearest pole to which two zip lines were connected. Measurements were conducted over a 10-minute period, during which activities occurred throughout the park, including a number of people passing along the zip lines nearest the measurement site. Figure 4 shows a time-history graph of the measured sound levels at Site 3. Two zip-line events are shown in the graphic that registered maximum sound levels of 58 and 56 dBA. The graph also includes a line showing the Leq ("equivalent" or energy-average sound level) for the period at 51 dBA.

Measurements on October 17, 2015

On Saturday, October 17, 2015 HMMH visited the outdoor deck of the Highview Condominiums to collect sound measurements, listen to the audible sources of sound and observe the weather conditions. As in August, measurements were conducted before the Adventure Park opened and again after it was operating at full capacity. The noise meter was placed near a picnic table on the Highview Condominiums' common building outdoor deck. Figure 5 is a photograph showing the noise meter measurement location on the condominiums' deck. This location is the closest seating area to the Heritage Museums property, and has direct exposure toward the Adventure Park, unshielded by nearby structures.

Saturday, October 17th was chosen for the measurements because the Heritage Museums' Adventure Park was open and expected to be busy, and because light winds from the west

and northwest were forecast. Such conditions are favorable to sound propagation from the Adventure Park to the Highview Condominiums. HMMH observed winds from the northwest and west during the measurement periods, and the wind data from the Otis Air National Guard weather station corroborates HMMH's observations. Also, the sky was clear or mostly clear throughout the measurement program.

Ambient background sound level measurements were conducted between approximately 8:30 AM and 9:00 AM, just prior to the opening of the Adventure Park. Average background sound levels during six 5-minute intervals ranged from 46 to 50 dBA, with the dominant sources of sound being traffic on Route 6 and Highview Drive, and birds; winds were calm or nearly calm during this early-morning measurement period.

HMMH returned to the Highview deck to conduct measurements between 11:00 AM and 11:30 AM, when the park was full with guests on the aerial courses. By this time of the morning, the background sound levels had increased slightly, due to increased traffic on Highview Drive, increased aircraft activity, and some contribution from wind in the trees. Local winds near the microphone were measured at speeds averaging 1 - 1.5 mph. Average sound levels during six 5-minute intervals ranged from 46 to 52 dBA, with maximum levels up to over 60 dBA from aircraft overflights and trucks on Route 6. A log of audible sound sources and events was kept during the entire measurement period, and at no time were any sounds from the Adventure Park or other activities at Heritage Museums and Gardens audible, including the maintenance shop, which was closed for the day.

Sound Level Prediction Based on Source Measurements

For the sound level prediction, HMMH used the standard, conservative inverse-square law sound propagation equation, and limited attenuation for terrain shielding and intervening foliage. The predicted Adventure Park sound levels at the Highview deck based on our reference measurements of normal operation of the park at full capacity are 15 dBA Leq (average) and 18 dBA Lmax (maximum event). These levels are so much lower than the ambient background sound levels in the area, that the background sounds completely "mask" (cover up) the sounds from the Adventure Park, such that they cannot be heard.

Our predicted maximum sound levels from human screams at the park (based on our roller coaster measurement data) if heard at the Highview deck are approximately 38 dBA. This level is near the quietest sound levels recorded at Site 1 during either measurement period. Therefore, such scream sound could be audible momentarily if it occurred during the quietest times of the 11:00 AM to 11:30 AM period. However, the level is sufficiently low and would be sufficiently infrequent such that it does not approach normal standards for annoyance or nuisance.

Please feel free to contact me if you have any questions or comments.
Sincerely,

Harris Miller Miller & Hanson Inc. d/b/a HMMH

Christopher W. Menge, INCE
Senior Vice President

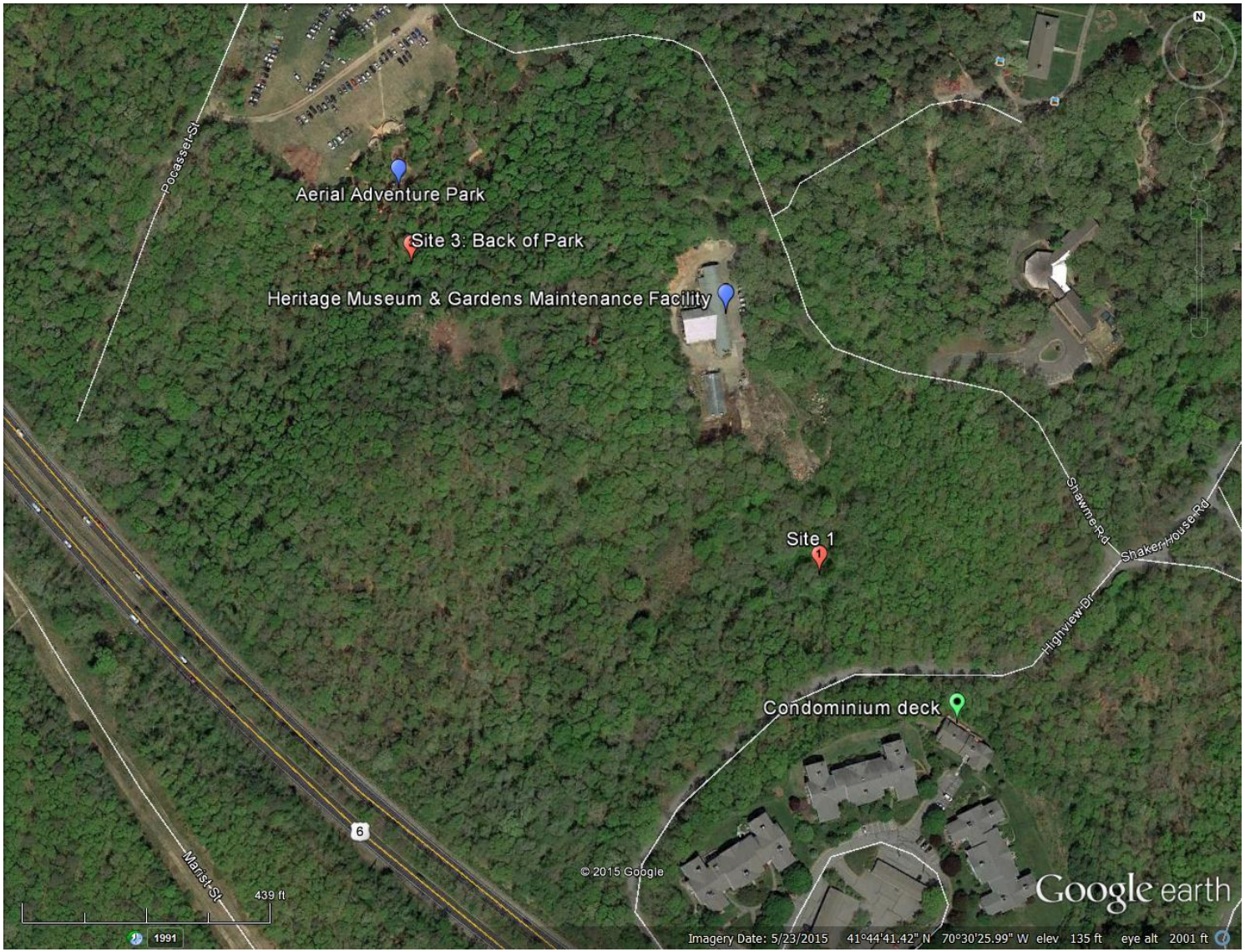

Figure 1 Aerial Photograph of Study Area Showing the Adventure Park, Condominium Deck and Monitoring Sites

Figure 2. Site 1: Ambient: Sound level time-history

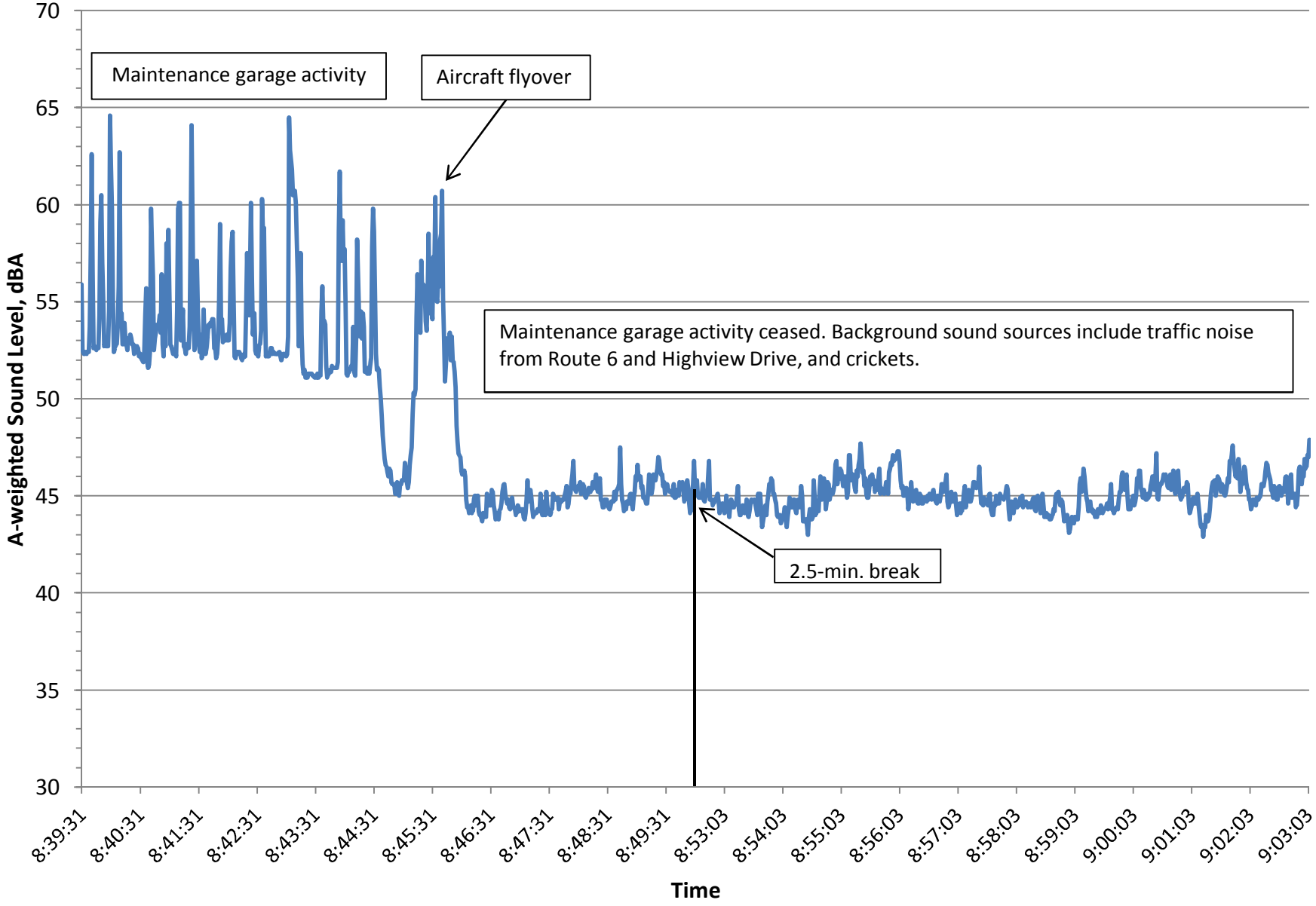

Figure 3. Site 1: Adventure Park in Operation: Sound level time-history

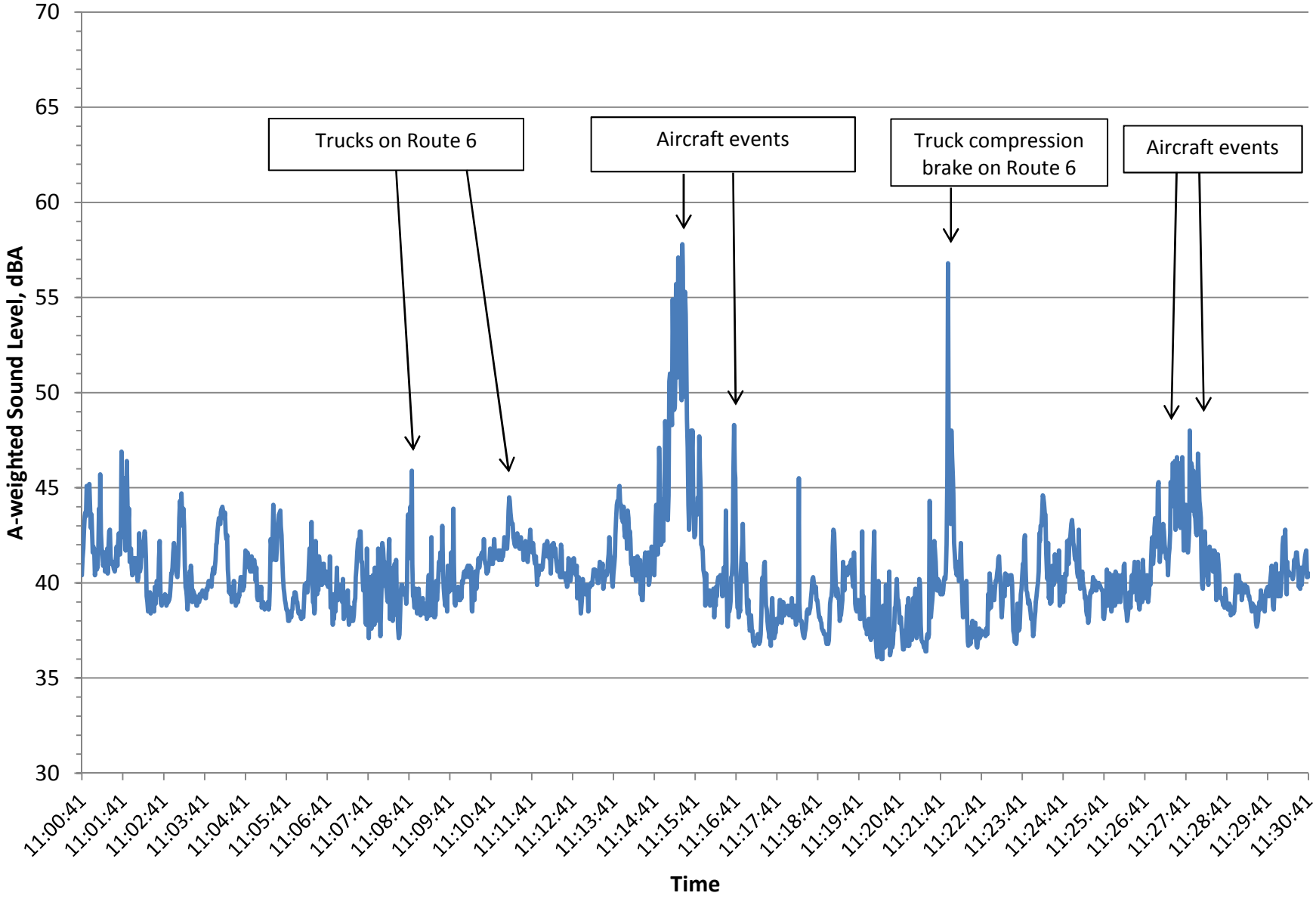

Figure 4. Site 3 Back of Park: Sound Level time-history

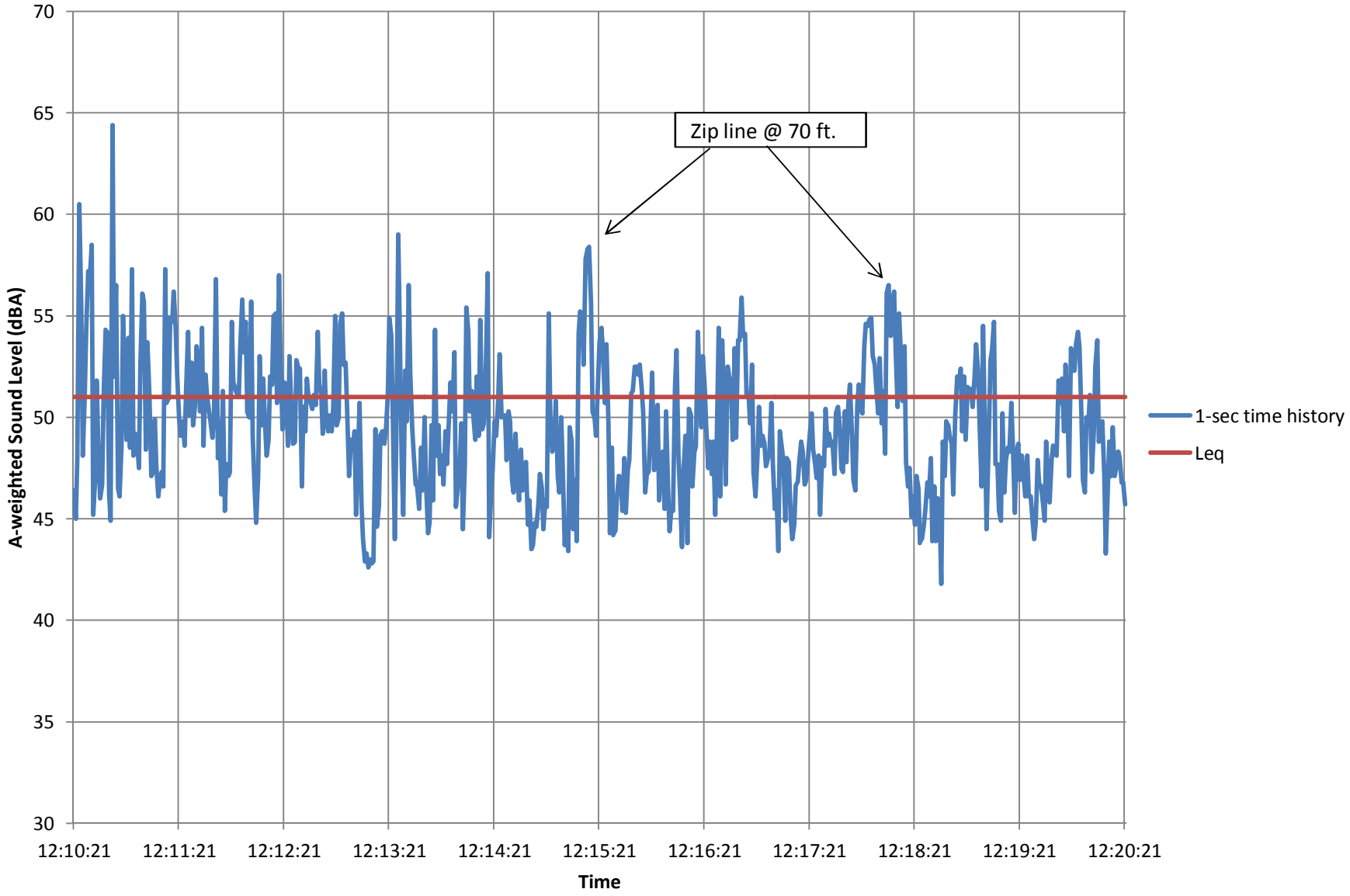

Figure 5 Photograph of Noise Meter Location on Highview Condominium Deck

APPENDIX A. DESCRIPTION OF NOISE METRICS

This Appendix describes the noise terminology and metrics used in this report.

Decibels (dB), Frequency and the A-weighted Sound Level (dBA)

Loudness is a subjective quantity that enables a listener to order the magnitude of different sounds on a scale from soft to loud. Although the perceived loudness of a sound is based somewhat on its frequency and duration, chiefly it depends upon the sound pressure level. Sound pressure level is a measure of the sound pressure at a point relative to a standard reference value; sound pressure level is always expressed in decibels (dB).

Decibels are logarithmic quantities, so combining decibels is unlike common arithmetic. For example, if two sound sources each produce 100 dB operating individually and they are then operated together, they produce 103 dB. Each doubling of the number of sources produces another three decibels of noise. A tenfold increase in the number of sources makes the sound pressure level go up 10 dB, and a hundredfold increase makes the level go up 20 dB. If two sources differ in sound pressure level by more than 10 decibels, then operating together, the total level will approximately equal the level of the louder source; the quieter source doesn't contribute significantly to the total.

People hear changes in sound level according to the following rules of thumb: 1) a change of 1 decibel or less in a given sound's level is generally not readily perceptible except in a laboratory setting; 2) a 5-dB change in a sound is considered to be generally noticeable in a community setting; and 3) it takes approximately a 10-dB change to be heard as a doubling or halving of a sound's loudness.

Another important characteristic of sound is its frequency, or "pitch." This is the rate of repetition of sound pressure oscillations as they reach our ears. Frequency is expressed in units known as Hertz (abbreviated "Hz" and equivalent to one cycle per second). Sounds heard in the environment usually consist of a range of frequencies. The distribution of sound energy as a function of frequency is termed the "frequency spectrum."

The human ear does not respond equally to identical noise levels at different frequencies. Although the normal frequency range of hearing for most people extends from a low of about 20 Hz to a high of 10,000 Hz to 20,000 Hz, people are most sensitive to sounds in the voice range, between about 500 Hz to 2,000 Hz. Therefore, to correlate the amplitude of a sound with its level as perceived by people, the sound energy spectrum is adjusted, or "weighted."

The weighting system most commonly used to correlate with people's response to noise is "A-weighting" (or the "A-filter") and the resultant noise level is called the "A-weighted noise level" (dBA). A-weighting significantly de-emphasizes those parts of the frequency spectrum from a noise source that occurs both at lower frequencies (those below about

500 Hz) and at very high frequencies (above 10,000 Hz) where we do not hear as well. The filter has very little effect, or is nearly "flat," in the middle range of frequencies between 500 and 10,000 Hz. In addition to representing human hearing sensitivity, A-weighted sound levels have been found to correlate better than other weighting networks with human perception of "noisiness." One of the primary reasons for this is that the A-weighting network emphasizes the frequency range where human speech occurs, and noise in this range interferes with speech communication. Another reason is that the increased hearing sensitivity makes noise more annoying in this frequency range. The figure below shows common indoor and outdoor A-weighted sound levels and the environments or sources that produce them.

Maximum Sound Level (L_{max})

The variation in sound level over time often makes it convenient to describe a particular noise "event" by its maximum sound level, abbreviated as $L_{max.}$ The maximum level describes only one dimension of an event; it provides no information on the cumulative noise exposure. In fact, two events with identical maxima may produce very different total exposures. One may be of very short duration, while the other may continue for an extended period and be judged much more annoying. The Sound Exposure Level metric corrects for this deficiency.

Equivalent Sound Level (L_{eq})

The Equivalent Sound Level, abbreviated L_{eq}, is a measure of the total exposure resulting from the accumulation of A-weighted sound levels over a particular period of interest -- for example, an hour, an 8-hour school day, nighttime, or a full 24-hour day. However, because the length of the period can be different depending on the time frame of interest, the applicable period should always be identified or clearly understood when discussing the metric. Such durations are often identified through a subscript, for example L_{eq1h}, or $L_{eq(24)}$.

L_{eq} may be thought of as a constant sound level over the period of interest that contains as much sound energy as (is "equivalent" to) the actual time-varying sound level with its normal peaks and valleys. It is important to recognize, however, that the two signals (the constant one and the time-varying one) would sound very different from each other. Also, the "average" sound level suggested by L_{eq} is not an arithmetic value, but a logarithmic, or "energy-averaged" sound level. Thus, the loudest events may dominate the noise environment described by the metric, depending on the relative loudness of the events.

Statistical Sound Level Descriptors

Statistical descriptors of the time-varying sound level are often used instead of, or in addition to L_{eq} to provide more information about how the sound level varied during the time period of interest. The descriptor includes a subscript that indicates the percentage of time the sound level is exceeded during the period. The L_{50} is an example, which represents

the sound level exceeded 50 percent of the time, and equals the median sound level. Another commonly used descriptor is the L_{10}, which represents the sound level exceeded 10 percent of the measurement period and describes the sound level during the louder portions of the period. The L_{90} is often used to describe the quieter background sound levels that occurred, since it represents the level exceeded 90 percent of the period.